

Rapidity Gaps in Double Diffraction Events at LHC as a Manifestation of String Junction Net on the Topology of Torus

Olga Piskounova

*P.N.Lebedev Physics Institute of Russian Academy of Science, Leninski prosp. 53, 119991
Moscow, Russia*

Abstract

The topological presentation of pomeron exchange at the proton-proton collision of high energy is cylinder that is covered with quark-gluon net. I suggest that the process of double diffraction (DD) can be presented as one pomeron exchange with the central loop of two uncut pomeron cylinders. Taking into account that the junction of three gluons (SJ) has the positive baryon number, as well as the antijunction is of negative baryon charge, our pomeron construction can be covered by only a certain number of hexagons with 3 string junction and 3 antijunction vertices each. It is reasonable to expect that the dynamics of rapidity gaps in DD should be determined by the number of hexagons on the surface of pomeron torus. Therefore, the gap distribution in DD events has the discrete structure in the region of large gaps. Moreover, the string-junction torus can be released in pp interactions as metastable particle and is getting suspected as Dark Matter candidate. The possibility of production of the states with many string junctions has been discussed recently by G.C. Rossi and G. Veneziano. There is another process with pomeron loop configuration that is the particle production events with doubled multiplicity at the central rapidity, which corresponds to the cut along the pomeron loop. The positive hyperon production asymmetries that have been measured at LHC are real demonstrations of string junction dynamics in the proton-proton interactions. These measurements have shown that the energy dependence of baryon excess in the central rapidity region depends on the SJ parameter. Therefore, the actual goal of LHC experiments should be the measurements of asymmetries in heavy baryon production that give us the precise value of the dynamical parameter of string junction: the intercept of SJ-antiSJ Regge trajectory. Furthermore, the detail study of the gap distributions in DD as well as the distributions of events with doubled multiplicity, which both go on the level of 1.2 percent of production cross section, seems also necessary.

1 Introduction

1.1 Measurements of Rapidity Gaps at the Double Diffraction Dissociation

The recent measurement of diffraction gaps in ATLAS has shown that the behavior of their distribution has different character in the different gap ranges¹. The histogram at the large values of gap in figure 1 indicates some discrete states of gaps. In this area only the process of double diffraction dissociation (DD) gives the contribution into the plot. Of course, the discrete pattern can be initiated by poor statistics. Nevertheless, we have to learn here the diagrams that lead to discrete levels of DD gap.

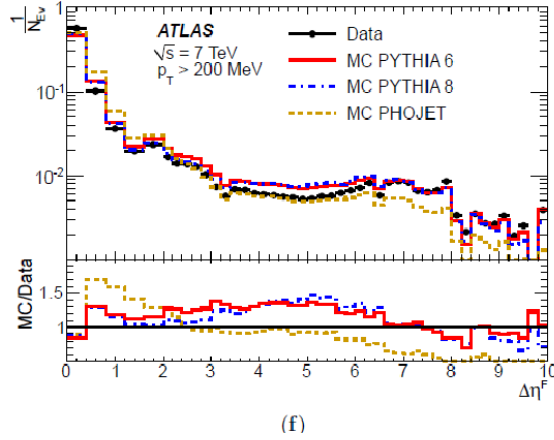


Figure 1: Forward rapidity gap distribution in ATLAS experiment.

1.2 Topological Expansion and Pomeron Exchange

Pomeron exchange is the topological QCD diagram that is responsible for multi particle production in p-p collisions at LHC energies. It was drawn in the topological expansion² as the cylindrical net of gluon exchanges with the random amount of quark-antiquark loops inserted between them. The topological expansion gives the chance to classify the contributions from general diagrams of multi particle production in the hadron interactions. The developing of this expansion has practically allowed us to build Quark-Gluon String Model (QGSM). Few orders in topological expansion are graphically presented in the figure from my PhD thesis figure 2, where the third order is named pomeron with handle. Double diffraction dissociation in this presentation looks like the cylinder of one pomeron exchange with the cylindrical handle. Pomeron exchange used to take 1/9 from the leading contribution of planar diagram with quark-antiquark annihilation on the energy scale \sqrt{s} is of the order 1 GeV. But the quark annihilation diagram is dying out with energy as $s^{-0.5}$ due to the regge behavior of quark-gluon diagrams. In the same time the cross sections of one pomeron exchange is to be growing as s^{Δ_P} , where the pomeron trajectory parameter $\Delta_P = \alpha_P(0) - 1 = 0.12$. Such a way the second order diagrams with the pomeron exchange have to be dominating at high energies.

1.3 String Junction and the Positive Baryon Production Asymmetry at LHC

Three gluon connections of Mercedes- type, or String Junctions (SJ), play an important role in the multi particle production in our positive-baryon-charge world as well as in p-p collisions. This object brings the positive baryon charge and generates the great asymmetry between baryon and antibaryon spectra in the region of diquark fragmentation. It is responsible also for the baryon production asymmetry at the central rapidity point in any collisions with proton matter. This asymmetry is surviving even at LHC energies that is a clear manifestation of SJ role, which is confirmed by available collider data⁷ figure 3. The recent data of ALICE have been added⁴. It will be shown in this article that the dynamics of DD gaps is obviously ruled by the Regge parameters of SJ trajectory too.

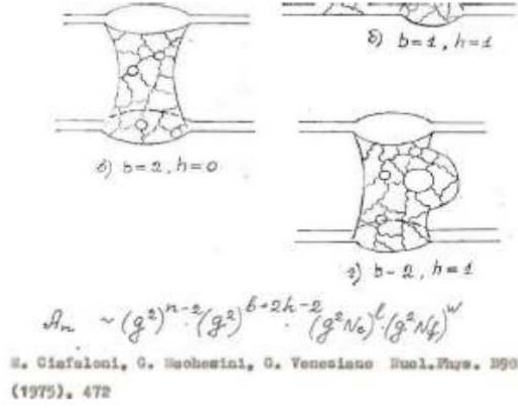


Figure 2: The fragment of graphical presentation of topological expansion, where b is the number of boundaries and h is the number of handles.

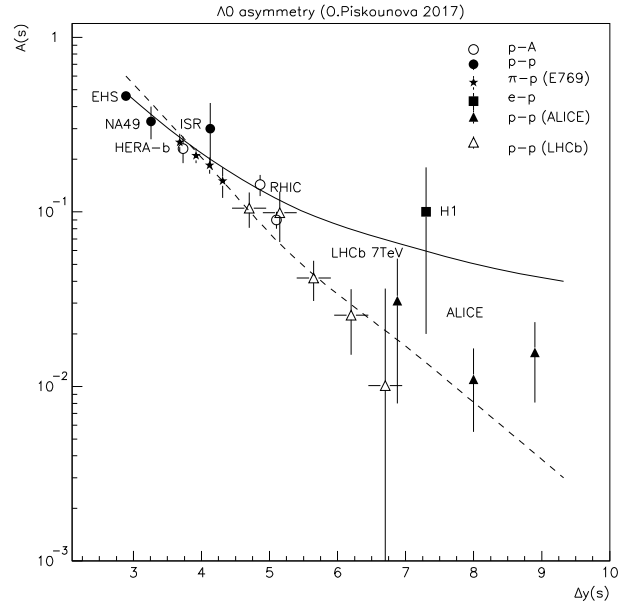


Figure 3: Hyperon asymmetry dependence on the the rapidity distance from center to the beam proton. Two theoretical lines correspond to the values of $\alpha_{SJ}(0)$: 0.9 - solid line and 0.5 - dashed line.

2 Double Diffractive Dissociation as an Exchange with Pomeron Torus

Double diffraction dissociation (DD) is a next order in the topological expansion after the pomeron exchange and should be presented as one pomeron exchange with two-pomeron loop in the center, see figure 4. Actually it is the topological

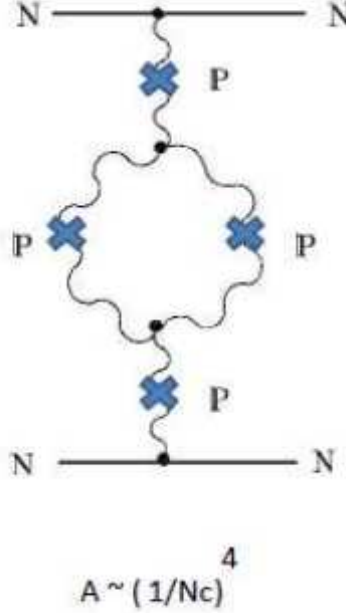


Figure 4: Two-pomeron loop in the center of one-pomeron exchange .

cylinder with a handle that takes $(1/9)^2$ from the pomeron exchange cross section (1,2 percent of σ_{prod}) at LHC energies. If the central pomeron loop was not cut, we are having the DD spectra of produced hadrons: two intervals at the ends of rapidity range, which are populated with multi particle production, and the valuable gap in the center of rapidity, see figure 5.

Looking at the two-pomeron loop in the diagram, we are realizing that it is torus in 3D topology. This interesting object should be considered separately in order to reveal some remarkable features for the experimental detection.

3 Junction-Antijunction Hexagon Net and Discrete Dynamics of DD Gaps

As we remember the pomeron cylinder is built by gluon exchange net, let us consider only three gluon connections on the surface of torus (or pomeron cylinder loop). This String-Junction type of gluon vertices has been studied in our early researches⁹. Since this object brings the baryon charge, the anti-SJ also exists and brings the

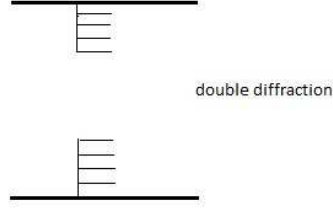


Figure 5: The diagram of particle multiplicity in the events with central gap.

charge of antibaryon. The only charge-neutral way to construct the net from SJs and antiSJs is hexagon where antibaryon charge is following the baryon one as it is shown in the figure refonecell. I would say that this is very entertaining game to close

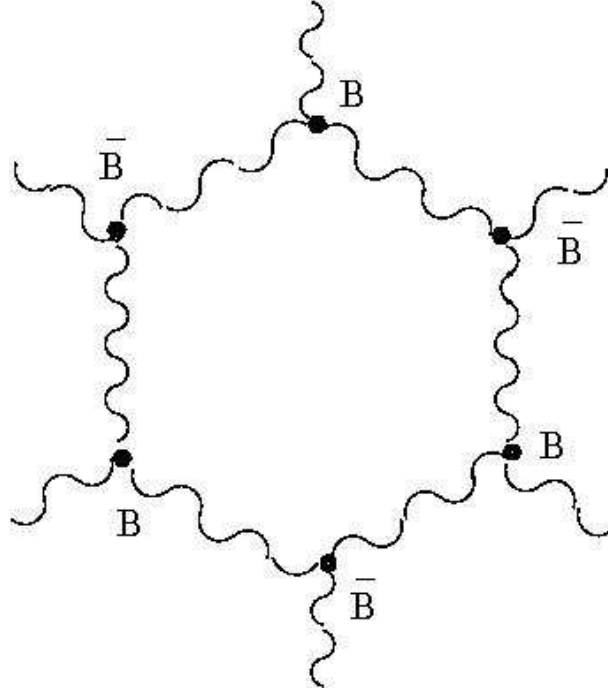


Figure 6: One cell of hexagon net with the string and anti-string junctions.

certain number of hexagons on the surface of torus! The closed net of six hexagons on the torus is shown in the figure 7. If people are trying to match the eligible number of hexagons, it becomes clear that there is a discrete row: Hexnumb=4, 6, 12, 16, 20, 30, 36, 42, 56 , figure 8. It means that the pomeron torus has certain levels of energy. Such a discourse leads to discrete gap states at DD.

4 Doubled Multiplicity at the Inclusive Hadroproduction as a Result of Pomeron Torus Exchange

We have to learn here the pattern with the torus cut as well, because this case of multi particle production is a version of the same diagram as in figure 4. The

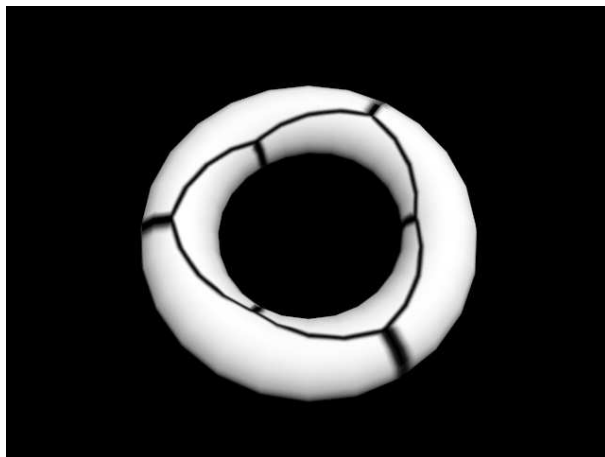


Figure 7: Six hexagons on the surface of pomeron torus.

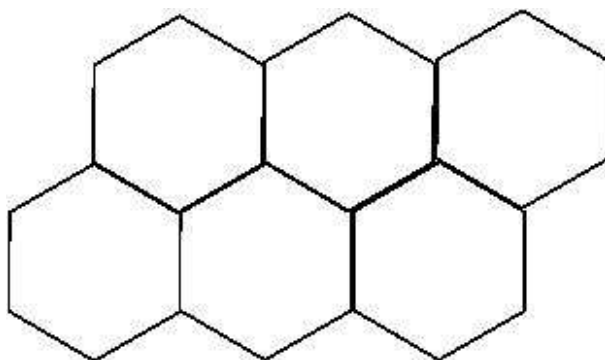


Figure 8: An example of six-hexagon net, which can be closed on the torus.

diagram figure 9 shows clearly that the same gap, which takes place in DD, is filled with particles of doubled density due to both sides of cut torus that gives twice as more particles per rapidity unit than one pomeron exchange produces. It is another evidence of our pomeron loop in multi particle production statistics. Such a way the doubled multiplicity intervals should have the same distributions as the gaps in DD statistics.

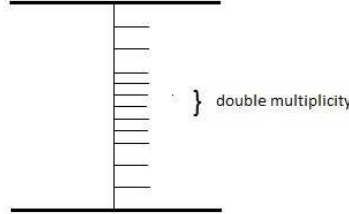


Figure 9: The particle production diagram with doubled density in the central rapidity gap.

5 More Suggestions on the Pomeron Torus

Here it is the place to imagine where the pomeron torus could contribute. What we have, if our gluon-junction construction that looks like a "compactified" pomeron string would be released as metastable particle? It is charge neutral QCD cluster with the certain potential energy, which is determined by number of junctions plus antijunctions. If such cluster would be stable, this is appropriate candidate for the dark matter (DM)⁸. The reason, why this object doesn't dissipate in the collisions with matter, is as follows: the atomic number of elements in the space is too small in comparison with the number of SJ-antiSJ vertices in our toroidal construction therefore compact torus leaves intact after the collision with the less stable atoms. Since each high energy proton collision in the space, wherever it takes place, contributes approximately one percent of energy into DM, the valuable mass has been accumulated in the Universe, even though some amount of energy dissipates back into baryons and mesons at the collisions with the interstellar atoms. As a result, we should have less dark matter in the places, where the atomic matter is concentrated.

6 Conclusion

The topological presentation of pomeron exchange at the proton-proton collision of high energy is cylinder that is covered with quark-gluon net. I suggest that the process of double diffraction (DD) can be presented as one pomeron exchange with the central loop of two uncut pomeron cylinders. Taking into account that the junction of three gluons (SJ) has the positive baryon number, as well as the antijunction is of negative baryon charge, our pomeron construction can be covered by only a certain number of hexagons with 3 string junction and 3 antijunction vertices each. It is reasonable to expect that the dynamics of rapidity gaps in DD should be determined by the number of hexagons on the surface of pomeron torus. Therefore, the gap distribution in DD events has the discrete structure in the region of large gaps. Moreover, the string-junction torus can be released in the course

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7 Acknowledgments

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